PEBB Quarterly Review
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PEBB Applications for Naval Aircraft

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PEBB Applications for Naval Aircraft

Objectives of Presentation

- Present the ratings of various Naval aircraft power electronics
- Compare aircraft ratings to various commercial and military applications
- Cite aircraft PEBB issues
- Increase NAVAIR participation

PEBB Applications for Naval Aircraft

Present Aircraft Power Electronic Applications

- Battery Chargers - 28 volts, 30-65 amps
- AC Generator Control Units - 115/200 volts
- AC&DC Combination Generator Control Units - 115/200 & 28 volts
- DC Generator Control Units - 28 volts
- DC-DC Converters - 28 volt, 4 amp
- Variable to Constant Frequency Converters - 10-65 KVA, 115/200 volts
- Inverters - 28 volts to 115/200 volts, 100-2500 VA
- Starter Generators - 30 volts, 200-300 amps
- Transformer Rectifier - 115/200 volts to 28 volts, 50 to 200 amps

Majority in 100 W to 2500 W range

PEBB Applications for Naval Aircraft

Developmental Aircraft Electrical Characteristics (V-22)

- Electrical Sources
  - 2 - 40 KVA Constant Frequency Generators
  - 2 - 50/80 KVA Variable Frequency Generators
  - 3 - 6/9 KW AC/DC regulated converters
  - 24 amp-hr lead acid battery

PEBB Applications for Naval Aircraft

Developmental Aircraft Electrical Characteristics (V-22)

- AC Loads: 75 total (115/200 V)

0 to 1 KVA	61.3%
1 to 5 KVA	25.3%
over 5 KVA	13.3%

- DC Loads: 156 total (28.7 V)

less than 5 amps	79.5%
5 to 12.5 amps	14.7%
12.5 to 22.5 amps	3.2%
over 22.5 amps	2.6%

PEBB Applications for Naval Aircraft

Future Aircraft Power Electronic Applications
(Joint Strike Fighter; Common Support Aircraft)

- Switch Reluctance Starter-Generator - 270 Vdc, 125 kW
- DC-DC Converters - 270 Vdc to 28 Vdc, 15 kW
- DC-AC Converters - 270 Vdc to 115/200 volts AC, 15 kW
- Solid-State Power Controllers - 270 Vdc, 5 to 50 amps
- Electro-Hydraulic Actuators - 270 Vdc, 100 amps

Majority in 100 W to 27 kW range

PEBB Applications for Naval Aircraft

Semiconductors in Use on Naval Aircraft

- Presently NAVAIR uses Mosfets, IGBTs and SCRs as the devices of choice for power electronic equipment on aircraft
- Aircraft electrical system designers, such as Smiths Industries, are not planning on using PEBBs in there advanced system architectures for Joint Strike Fighter and Common Support Aircraft

PEBB for Naval Aircraft

Will MCTs be the semiconductor of choice for Naval aircraft ?

PEBB Applications for Naval Aircraft

Other PEBB Applications Ratings

- Air Force
  - AC Voltages - 200/115 volts, 400 Hz
  - DC Voltages - 28 volt, 270 volt
  - KW - 0.1 to 125 KW
  - Majority < 30 kW
- Naval Shipboard
  - AC Voltages - 450 volts, 60 and 400 Hz
  - DC Voltages - 28-270 volt (Present), 1000 volt (Future)
  - KW - 1-300 KW (Present), 20 MW (Future)
  - Majority (1-50 KW)

PEBB Applications for Naval Aircraft

DDG-51 FLTIIA SWBS 500 Survey

- SWBS 500 is all auxiliary machinery
- 452 electrically powered loads were identified as having “PEBB” potential
- 3% were over 100 KW_
- 30% were between 5 and 100 KW_
- **67% were less than 5 KW**

PEBB Applications for Naval Aircraft

PEBB Aircraft Application Issues

- Lower switching losses
- Lower conduction losses
- Thermal - must be air cooled, operating temperatures -55 degC to +85 degC
- Reliability (5000 hr MTBF; life cycle costs)
- Vibration (packaging)

PEBB Applications for Naval Aircraft

NAVAIR Participation

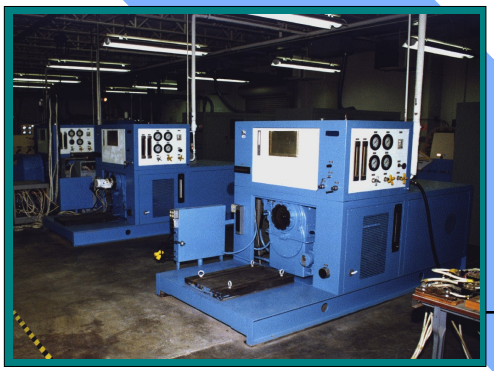
- 6.2, 6.3, 6.4 type of work
- Test and Evaluation capabilities
- Presently no tasks identified for PEBB related work in any programs

Electrical Power Systems Division

Naval Air Systems Command
Patuxent River, Maryland
(301) 342-4161

Test Capabilities

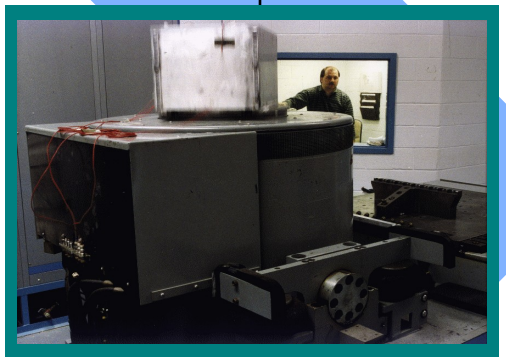
Building 1461



Aircraft Electrical Power Evaluation

Portable Environmental Test Facilities

MIL-STD-461 Electromagnetic Interference



Vibration Facilities

Combined Environmental Test Facilities

The Electrical Power Systems Division, of the Propulsion and Power Engineering Department, provides the engineering personnel, processes and facilities to provide support for all Navy propulsion and power aircraft electrical power systems. The support includes technology development, integration design analysis, test and evaluation, and maintenance engineering for all electrical power system components (e.g. AC and DC generator systems, electrical starters and starter/generators, power conversion components, batteries, external power monitors and power management systems). The Division conducts complete electrical system laboratory, ground and flight test as well as related analytical and fleet investigative tasks. The Division also supports the Naval Aviation Systems Team environmental test laboratory used for conducting complete environmental testing on a wide variety of airborne and ground support equipment. Building 1461, a 40,000 square foot facility, houses the electrical, environmental and mechanical test facilities with separate wind tunnel and a mobile laboratory. The environmental test facility is capable of simulating nearly every atmospheric and mechanical condition encountered by modern aircraft systems. The Division also provides the experienced personnel for aircraft inspection of system installations or the entire aircraft for specification compliance, workmanship and safety of flight. Readily available Navy aircraft and extensive airspace provided by the NAWCAD Patuxent River make it possible for complete laboratory, ground, and flight testing.

Aircraft Electrical Power Evaluation

Test Stands
- 4 - 30 HP
- 2 - 50 HP
- 4 - 200 HP
- 5 - 300 HP

Speed Range
- 0 to 30,000 RPM

Acceleration/Deceleration
- 45 to 1800 RPM/second

Electrical Loads
- AC - 123 KW, 93 KVAR at 115/208 VRMS & 400 HZ
- DC - 500 Amps at 30 VDC
- DC - 720 Amps at 270 VDC
- DC - 35/70 KW Active Load Bank at 270 VDC

Air Cooling
- up to 1400 CFM (room ambient)

Oil Cooling
- up to 10 GPM
- up to 425 PSI
- 100 to 350 degrees F

Aircraft Electrical Power Compatibility

User Equipment compliance with MIL-STD-704 (Aircraft Electric Power Characteristics)

Operational Compatibility of User Equipment with any Electric Power System used on Navy Aircraft

Data Acquisition & Control Systems

Portable System for Off-Site Use

Modular Components for Multiple Configurations

Software for Windows & MS DOS

Standard Configuration
- 70 Voltage Readings (mV, Vdc, Vac (300 V_{peak})
- 20 Temperature Readings
- Capable of Recording 4 Generator Systems
- (3 phase Vac, Hz, Amps, Watts, PF, %THD)

Control:
- 40 SPST Switches
- 5 - 300 HPO Drivestands
- 5 - 123 KW/93 KVAR 115V 400Hz Load Banks

Engine Starting Simulation

2 - Jet Engine Drag Torque Simulators

200 HP Capability (Maximum Starter Transient Response (Limited to about 65 HP)

Dual Channel, Cross Start Capability

Complete Aircraft Mission Electrical Power Simulation Capability

Drive Interface Simulation

Environmental Test Capabilities

Temperature/Altitude
- -70 to +125 degrees C
- Sea Level to 100,000 Ft
- Chamber Volume to 343 Cu Ft
- Interface for Shaft Driven Equipment

Temperature -65 to +160 degrees C

Humidity
- 20 to 95 Percent RH
- 20 to 95 Percent RH
- Chamber Volume to 24 Cu Ft

Salt Fog/Spray
- All Salinities
- Chamber Volume to 70 Cu Ft
- Stack Gas Simulation

Vibration
- 5 - 2,000 Hz Sine/Random
- 24,000 Lb Force, Sine
- 20,000 Lb Force, Random

Dust
- Density, 0.3 + 0.2 Grams/Cu Ft
- Velocity, 300 200 & 1750 250 Ft/Min
- Chamber Volume to 80 Cu Ft

Fungus
- 5 Types
- Chamber Volume to 24 Cu Ft

Conditioned Forced Air
- 2.0 to 40 Lb/Min; -70 to +140 degrees C
- 0.2 to 2.0 Lb/Min; -60 to +150 degrees C
- Temp/Alt Chamber Interface

Shock
- 160 G Peak
- 70 Inch /Second Velocity
- 1.0 Inch Displacement Peak to Peak
- half Sine, Sawtooth, Rectangular

Temperature/Altitude/Humidity
- Portable (wheel mounted)
- Simultaneous Programmable Conditions
- Chamber Volume to 15.5 Cubic Feet

Interface for Shaft Driven Equipment

- Rapid pull down rate from ambient to -65 degrees C in 15 min (empty chamber)
- Humidity 20 to 98 Percent RH
- Altitude Sea Level to 100,000 ft
- Interface for Shaft Driven Equipment

Temperature/Vibration/Humidity/Forced Air
- Combined Environmental Conditions
- Simultaneous Programmable Conditions
- Simultaneous Programmable Conditions
- Chamber Volume to 64 Cubic Feet
- Temperature -73 to +177 degrees C
- Vibration: 5 - 2,000 Sine/Random
  4,000 lb Force Sine/Random
- Humidity 20 to 98 Percent RH
- Forced Air: 0.2 to 10 lb/min
- -65 to +85 degrees C

Wind Tunnel Testing

Ram air turbine generator test capability
Velocity to 230 kts
Cylindrical test section 6 ft long, 3 ft diameter

MIL-STD-461
Electromagnetic Interference
(available on site)

2 Anechoic Shielded Enclosures
- 20 X 15 X 10 Foot Welded Enclosure
- 20 X 14 X 10 Foot Panel Enclosure

National Voluntary Laboratory Accreditation Program (NVLAP) Certified
NARTE Certified Engineers

Shaft Driven Equipment Interface
- Loads to 200 HP
- Speeds to 30,000 RPM

MIL-STD-461/462 Compliance

Emissions Testing From 20 Hz to 40 GHz
Susceptibility Testing from 20 Hz to 40 GHz
Field strengths up to 200 V/Meter from 10 KHz to 40 GHz
Transients up to 800A at 3,200 Volts
Mode Stirring up to 600 V?Meter
Frequency Stirring up to 600 V?Meter
E Probe Monitoring/Leveling System
EMP Pulser up to 50,000 V/Meter
Spherical Radiator Reference Standards

PEBB Applications for Naval Aircraft

Conclusions

- Aircraft application requirements are similar to automotive, commercial, and Navy shipboard
- Aircraft applications for PEBB require characteristics (electrical and environmental) other than those currently being developed by the Navy under the PEBB program